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ABSTRACT

This digest provides research on curriculum and assessment in the age of Computer Algebra Systems (CAS). The digest presents research on assessment with CAS technology, teacher accounts of assessment with CAS technology and curriculum issues. (Contains 18 references.) (MM)

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By

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Digest

Curriculum and Assessment in an Age of Computer Algebra Systems

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The use of Computer Algebra System (CAS) technology in the teaching of mathematics is entering a new and crucial stage. A considerable amount of work to date has focused on support of existing curriculum topics and existing curriculum models. Kutzler's seminal book on teaching and learning using DERIVE (1996) includes the phrase "here is an example of how CAS can be used to support an existing curriculum topic". Arguments for the use of CAS as an effective tool in supporting teaching and learning of mathematics are well established. Now comes the real work.

Curriculum models and assessment of curriculums are the structures that schools and examining boards create to educate students. The two are deeply connected and the real work of CAS advocates is now to develop curriculum models in which the use of CAS is an integral part, not just of the practice of the curriculum, but, of the conception of the curriculum. A thorough examination of topics must be carried out to decide what really has to stay for conceptual reasons and what is still extant only because of tradition.

A crucial part of this process is a demonstration of assessment using CAS. Unless instruments can be found to measure the achievement, or lack of achievement, of that learning which is possible through the use of CAS it is destined to remain as a prop occasionally brought out to support and bolster existing methods of teaching and learning.

We should take the current topics, the current models and using those topics see how we can begin to assess students who are answering examination questions with CAS as an aid. This exercise serves the very useful purpose of bringing to light the relative triviality, in a CAS age, of some common current questions and forces us to examine their real significance as mathematical concepts. The close scrutiny of current examination questions also affords the possibility for the incorporation of more complicated questions previously beyond the scope of a time-limited written examination.

Research on Assessment with CAS Technology

A vital issue is "How much is a question testing mathematics and how much is it testing ability to use technology?" There is value in both, but there is a distinction. Kokol-Voljc (1999a) chose to make this distinction by setting up a matrix with four categories which answer two questions: (a) Is the technology immediately put to use in answer to the question or does some work need to be done first (i.e. Is the use of technology primary or secondary?), and (b) Once the technology is being used are the operations straightforward or does the student need good ability in using the technology (i.e. Is the use of the technology elementary or advanced?). Kokol-Voljc has written more extensively about the classification which has been refined and expanded in various ways (1999b).

Several have examined the impact of CAS on current national examinations with questions posed about the future of such examinations in the CAS age. Aogáin (2000) looked at the Irish Leaving Certificate Examinations for 1999 and classified questions as trivial, easy, difficult or CAS proof. He proposes a calculation of an "index of suitability" for examinations that could be applied to any examination.

A review of examinations in several European countries was undertaken by Drijvers (1998) who noticed several approaches and classified them according to the extent to which technology is allowed and, if allowed, the reward available to those who use it.

Brown (1999) compared some examination questions from Australia, Denmark and the USA and noted the clear difficulties that examining boards are having in finding an appropriate approach to assessment. He offers the view that "There will undoubtedly be an evolution in the development of setting questions that encourage the use of technology while ensuring that the primary focus of the mathematics assessment will remain on assessing mathematical concepts and understanding." Others working in this area include Fazio (2000), Lokar & Lokar (2000) & Ruthven (1997).

Kutzler (2000) makes the case for two-tier examinations, one part with no technology allowed and a second part with any and every technology allowed. As Kutzler says "Two-tiered exams would be a well-balanced compromise meeting both the desires of technology supporters and the reservations of those who are concerned about the use of technology in the classroom."

Teacher Accounts of Assessment with CAS Technology

The discussion of assessment must be more far reaching than summative examinations, and several articles address this wider discussion. Many of these are in the form of teachers relating personal experiences of trying to incorporate CAS technology into their teaching and assessment.

Torres-Skoumal (2000) found group assessment very effective both for improving technical competencies and mathematics achievement. Other benefits she observed were social integration, student awareness of assessment procedures, and improvement in use of mathematical language.

Kempski (1988) uses DERIVE in the teaching and assessment of mathematics. Based on several years of experience he suggests that "students who best use the software are those who are more able and confident in Mathematics." Kempski also considered the way that students used DERIVE in examinations and was interested to observe that "more often than not, they demonstrated an inability to make the best use of the software and did not even take full advantage of the routine menu commands."

The proceedings of the 6th ACDCA Summer Academy in Portoroz, Slovenia, published under the title "Exam Ques-

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tions & Basic Skills in Technology-Supported Mathematics Teaching (Proceedings Portoroz 2000)" (Kokol-Voljc et al, 2000) contains many more articles related to teaching, learning and assessment in the CAS age.

Curriculum Issues

The question of curriculum itself in a CAS age is at the early stages of discussion. Some researchers (Heid, 1988 and Cabezas & Roanes-Lozano, 1998) are looking at the sequencing of certain topics. McCrae and Stacey (2000) are investigating "the changes that regular access to CAS calculators may have on senior secondary mathematics subjects and to explore the feasibility of offering new subjects that use CAS extensively." Students in three volunteer schools have been participating in the study which will likely result in formal assessmen in a CAS-active environment only. The project web site is www.edfac.unimelb.edu.au/DSME/CAS-CAT/.

Heugl (2000) has listed what he sees as seven important competencies in algebra, such as the competence of recognising structures, recognising equivalence of terms, and visualisation. He discusses the seven competencies in terms of the impact of CAS on them, and he suggests several different examination models which may prove more responsive to the impact of CAS than traditional examinations.

Finally, a very controversial addition to the debate is the paper arising from the discussion between Herget, Heugl, Kutzler and Lehmann (2000) about what they consider to be the essential skills in arithmetic and algebra in the CAS age. They imagine an environment of a technology-free examination and classify problems into essentially two types: those questions which a student would be expected to answer in such a technology-free examination (i.e. without any calculator or computer), and those questions which would not be asked in such an examination. A third group in the classification are those questions about which the authors have doubts as to where to classify them. The authors stress that those questions that they would not ask in a technology-free examination they find inappropriate for any examination, even one where powerful technology is allowed. As they say "we would not ask these questions in a technology-supported exam either, because these questions appear useless as such, their best use might be to test how well a student can operate a calculator." The paper is intentionally controversial and as the authors themselves say "we deliberately wanted to be provocative and shake the mainstay of traditional mathematics teaching."

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